UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C. 20250

REPORT AND RECOMMENDATIONS
of the
FARM RESOURCES AND FACILITIES RESEARCH ADVISORY COMMITTEE
Developed at its Meeting
October 25-29, 1965
Ames and Council Bluffs, Iowa

FARM RESOURCES AND FACILITIES RESEARCH ADVISORY COMMITTEE

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Additional copies of this report may be requested from David J. Ward, Executive Secretary, Farm Resources and Facilities Research Advisory Committee, Research Program Development and Evaluation Staff, U.S. Department of Agriculture, Washington, D. C. 20250

PREFACE

The Committee reviewed cooperative research programs of the Soil and Water Conservation and Agricultural Engineering Research Divisions of the Agricultural Research Service and related research conducted by the Natural Resource Economics Division, Economic Research Service. It considered annual Progress Reports and other resource materials describing research activities. Research leaders briefly described the programs, discussed some accomplishments, and defined important research needs. Some Federal and State scientists associated with the Iowa Agriculture and Home Economics Experiment Station and other research installations in nearby states described local and regional field and laboratory research and gave several on-site demonstrations of procedures, achievements, facilities, and problems yet to be solved.

Mr. G. L. Mehren, Assistant Secretary and Acting Director of Science and Education, is Chairman of the Committee; Dr. H. A. Rodenhiser, Deputy Administrator for Farm Research, Agricultural Research Service is Vice-Chairman.

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GENERAL COMMENTS

Water as a resource and its relation to the land and people's environment has become a critical concern to all people. The extreme drought of the Northeast and excessive flooding in other parts of our nation have dramatically emphasized the associated and unresolved problems of water as it relates to the human and physical welfare of our society. In a technological age, agricultural research has become a recognized and established way of solving such problems. The three most pressing problems are:

1. Providing a plentiful water supply
2. Protecting the land resources from floods and erosion
3. Preventing the deterioration of the quality of water on and beneath the rural lands of our country

The Committee notes with gratification that the Congress has provided additional funds for the Department in F.Y. 1966 to be used for further implementation of highest priority items in Senate Document 59, 86th Congress, entitled "Facility Needs--Soil and Water Conservation Research." At the same time, the Committee is concerned that the Department has not emphasized implementation of Senate Document 59 in its budget presentations to the Congress and recommends that such requests be included in future budget presentations.

The Committee reiterates its strong recommendation for substantially expanding agricultural engineering research. In addition to a need for more basic research, there should be an increase in agricultural engineering research cooperative and concurrent with other related agricultural research programs. Whenever appropriate, this cooperation should involve industry as well as publicly supported research.

In many operations, the mechanization of American agriculture still largely involves the substitution of machines for man and animals. The Department should initiate agricultural systems analyses that may result in more crop and livestock production systems based on machine performance specifications instead of how jobs have been performed traditionally.

The Committee wishes to recognize the degree to which the USDA, States, and Industry are cooperating on research endeavors. Since all agencies are working toward the same goals, i.e., reaching for basic principles and practices that will benefit all people, urban and rural alike, the Committee believes that such cooperation should be continued in general and expanded in those areas of research that seem feasible. Where possible, the collaboration of staffs of the USDA and Land Grant College and Experiment Stations and the joint use of facilities will result in the use of more professional talent and the involvement of a greater number of scientific disciplines in the search for knowledge needed to solve today's agricultural problems.

The long-range study of agricultural research needs being conducted jointly by the USDA and State agricultural experiment stations is noted with satisfaction. The demand will increase for an adequate supply of high quality food and fiber, effective conservation and use of natural resources, and for new knowledge about social and economic aspects of a changing agriculture. It is important that support for research be adequate and directed toward the solution of the most important problems.

The Committee continues to support the strengthening of basic research and an increased emphasis on the quest for new knowledge. The identification of the structure of an alanine transfer ribonucleic acid, (the first nucleic acid for which the structure is known) by scientists at the U. S. Plant, Soil and Nutrition Laboratory is recognized as an outstanding scientific contribution. In addition to shedding new light on basic life processes, the finding serves as a building block for developing and understanding of how proteins are manufactured in plants and animals.

Some USDA funds are being used in extramural research programs. The Committee strongly supports in principle the policy of awarding funds through the USDA to provide contracts and grants to universities and colleges for the collaborative development of basic research in specified areas of mutual interest. This would (1) permit colleges and universities to reduce the diversion of their staffs to nonagricultural research pursuits, (2) further encourage the use of more personnel to plan and execute needed research, and (3) permit the advanced training of young scientists needed to meet the demand for such personnel.

Progress in implementing Department objectives for assuring that professional research and education personnel are adequately trained to meet changing program requirements is noted with pleasure. Specific authority should be sought for providing graduate fellowships and scholarships, similar to such programs as the National Science Foundation, to help assure an adequate supply of well trained scientists who are especially oriented toward the problems of agriculture.

Concern is expressed about ceilings imposed on the number of scientists holding positions in upper civil service salary levels. The Committee applauded the "Man-in-the-job" concept developed in the Department wherein a scientist's salary is commensurate with his productivity and is measured without regard to the salary of research administrators with whom he works. Ceilings restricting the application of the concept are resulting in the loss of talented scientists and are having a detrimental effect on recruiting.

CONSERVATION, DEVELOPMENT AND USE OF
SOIL, WATER AND RELATED RESOURCES

Natural Resource Economics

With rapidly changing national and world conditions, more natural resource economics research is needed. Public investments in national agricultural land and water programs should be evaluated as to benefits and costs in the following particulars:

a. Distributional effects of area land use adjustments
b. Cost-scale efficiencies of individual farming operations
c. Alternate multiple uses of rural lands, including recreational developments
d. Impacts of new technology and farm mechanization processes on land use adjustments
e. Implementation of water quality management programs, including use and disposal of lower quality waters.

Projections of man's food, fiber and environmental requirements in light of technological and marketing developments, population shifts and increases and changing national and international responsibilities should be constantly related to the need for the development of domestic agricultural policies. Intensification of efforts to improve the farmer's economic position and to maintain agriculture's potential to meet increasing and changing demands is strongly recommended.

There should be further continuing work to more fully integrate the research efforts of the Soil and Water Conservation, Agricultural Engineering and Natural Resource Economics Research Divisions.

Water and Related Land Resources

The importance of making the best use of water as it relates to the land resources and to the people of our country makes it imperative that we increase our research efforts in the following fields:

(Hydrology)

The development of adequate water supplies requires the efficient use of surface water and ground water conjuntively. Obtaining economically a balanced development must be the result of comprehensive studies of the hydrologic cycle. Hydrologic research of the Soil and Water Conservation Research Division appears to be directed toward the necessary aspects. However, it is recommended that added emphasis be placed on problems associated with the use and recharge of groundwater. This should be well coordinated with other Federal and State investigations. The need for research in the area of hydrologic measurement instrumentation is reiterated.

(Sedimentation)

Control of sediment, as it affects our land resources and water supply, is necessary to protect our agricultural land, reservoirs, harbors, stream channels, streets and highways, and flood plain lands. More emphasis needs to be directed toward research on upstream agricultural watersheds as they relate to land use and conservation practices--particularly source of sediment, channel stabilization, and sediment transport.

A serious sediment and runoff problem often arises when agricultural land use changes to urban and suburban land use. With the concerted effort on sedimentation conducted by the Agricultural Research Service, it seems imperative that the Department take responsibility for leadership in calling this problem to the attention of all interests concerned and to work for coordination of these various interests for more research on this problem.

(Irrigation and Drainage)

Research concerned with irrigation and drainage is a necessary part of providing water of both adequate quantity and quality. Research to further improve standards for water control structures should be expanded within the framework of existing Department facilities and allied agencies involved in such research. Pressures to increase efficient use of irrigation water make it important to emphasize research toward this end. This should be a joint responsibility of the several public and private agencies.

With increasing use of water for irrigation and with natural high water tables in many humid regions, drainage research will prove essential to land use and make for efficient use and control of water. Improved design, materials, techniques and methods of drainage appear to be deserving of major emphasis. All of this research needs to be integrated with the research on soil-water-plant relationships.

(Water Quality Control)

Research efforts to prevent the deterioration of the quality of water on and beneath rural lands should be a major concern of the Department. How contaminants, pesticides and sediment affect the quality of stored surface water, flowing streams and ground water supplies is important in the cyclic use of water for crops, wildlife, recreation and domestic and industrial supplies. There is need for a greater effort by agriculture to press research for a solution of water quality problems for the benefit of our nation's agricultural economy and society as a whole. As research is expanded on atmosphere or soil-derived materials in agricultural waters, attention should be directed to obtaining information about the effects of such materials on the nutritive values of foods and feeds.

(Wind and Water Erosion)

Protecting the surface of crop, forest, and range lands, and the channels of agricultural watersheds merits continued research. Fundamental research on characteristics and patterns of winds as related to storms, both rain and

snow, is needed to provide information for conservation practices to prevent erosion. This needs an interdisciplinary approach.

(Moisture Conservation)

Soil and water conservation is everybody's responsibility. Research on improved efficiency in conveyance of water, reduction of evaporation, and transpiration (with adequate emphasis on brush control), soil sealing, and ground water use and recharge represent areas which need continued study. Here again this needs a carefully correlated program delving into the interrelationships of soil, water and plants. Agricultural water uses have a considerable impact on the overall water budget of an area that may include urban society.

Soil Properties and Management

Soil properties and processes are important because of their effects on plant growth and water quality and use, as well as on site locations, for the development of new rural industries. Recent basic investigations which measure and evaluate soil structure and water and gas movement appear to have much practical significance. Also, efforts to modify soil profiles physically and chemically appear to have high potentials for the furtherance of efficient crop production.

Deserving of special recognition is the work which has been done in the development of accurate methods of determining pesticides in soils and the experiments which have been initiated to evaluate the influence of different crop residue management systems on the conservation of water. Both study areas related to problem situations which are of vital concern to the agricultural industry.

Strong emphasis should be given to the following lines of research:

A knowledge of nutrient activity in the soils and how nutrients are taken up and translocated by the plant is basic to and needs emphasis for an understanding of the development of crops of high quality and diagnosing nutrient requirements. The influence of one nutrient on the plant's need for another nutrient also needs to be understood.

In all areas of research, a means is needed to characterize soil structure as it is related to the flow of water and gases into and through soils. Highest priority should be given to developing a quantitative method for measuring and evaluating soil structure. Interpretations of soil structure for land suitability classifications also are deserving of consideration.

In order to determine the possibility of contamination of surface and ground water supplies, research is needed to identify the sources of nitrates, whether native to the soil or added, and to determine their movement into water supplies. Such questions as the environment where nitrification occurs need to be answered.

Application of waters of various qualities to soils, both for irrigation and waste disposal purposes, creates problems of soil salinity and contamination of water supplies through leaching. Methods are needed for predicting the effects of applying waters of various qualities to soils. Continued emphasis on research on salt-tolerant crops, efficient means for using and reusing poorer quality water supplies and the safe disposal of waste waters is necessary.

A related area of investigation is the interpretation of soil characteristics generally for rural and recreational land use planning and development. Guidelines are needed to help identify soil areas which are well adapted to different land uses in developing rural economies. Use restraints and hazards need to be identified. Information concerning land use potentials needs to be made more readily available in advance of development to guide enterprise location.

Tillage and Soil-Machine Relationships

Tillage of the soil is the greatest consumer of power in the production of crops in the United States today, requiring about 30 percent of the energy for all farm operations. To improve tillage methods we must be able to specify soil conditions that are needed for any crop and the equipment and soil treatments that will produce a specific condition. Methods and instruments for measuring the condition of a soil must be developed.

Improved methods in the utilization of all crop residues are highly desirable to increase soil organic matter and water intake. Attention should be directed to the development of tillage practices, such as mulch farming or other methods, that have proven to be effective in the conservation of soil and water and to seeking the most practical and economical ways in which these practices can be applied by the farmer for best results. Research engineers should be encouraged to develop better equipment for handling heavy crop residues most effectively and for seeding and fertilizer distribution and placement.

Since soil compaction is a problem in many parts of our nation, it is recommended that work of National Tillage Machinery Laboratory in this field be pursued to the fullest.

Soil - Water - Plant Relationships

Earlier in this report concern was expressed about the need for information on ways to achieve maximum conservation of the national water supply. This makes mandatory a full understanding of the mechanisms by which losses occur from the soil through the vegetative cover. As yet, there is insufficient basic understanding of the phenomena by which water moves through varying soils into and through different plant species under differing meteorological conditions.

It has been estimated that 70 percent of the entire water budget is used in the process of evapotranspiration from the soil reservoir. This use points up the urgency for greater knowledge, not only for the purpose of maximum conservation of the supply, but also for basic understandings on which to base recommendations for other related research and action programs having to do with matters such as moisture conservation, soil management, irrigation and drainage.

Nutrition of Animals as Affected by Properties and Characteristics of Soils and Plants

Increased knowledge of the many factors involved in the production of human and animal food having the quality needed for proper nutrition is urgently needed. Identification of quality factors (and limitations) in plants and their methods of synthesis would contribute greatly to the solution of food problems. Of immediate concern is a need to identify the factors affecting and mechanism of formation of high quality protein in plants. Increased emphasis should also be placed on the pathways followed by micronutrients from soil to plant to animals, including interaction of micro- and micronutrients at all stages along the food chain.

Photogrammetry

Although some use has been made of infrared photography in soil and water research, much greater opportunities appear to be possible as new information and techniques in remote sensing photography become available. Its application in identification of crops, soil and crop deficiencies, insect disease and weed infestations, and soil classification, and fertility levels makes it a valuable research tool worthy of development as rapidly as possible.

EFFICIENT PRODUCTION AND QUALITY IMPROVEMENT

Planting and Fertilizing Operations and Equipment

There is considerable present need for information about precise seedbed requirements for various crops in different areas of the country. This should include information about optimum depth of cover, size of soil particles or clods surrounding the seed, degree of soil compaction necessary, and soil surface profile over the seed for best emergence.

The row spacing used on many crops is still that which was necessary to permit horse cultivation. The best planting geometry for many crops is still unknown. The best placement for starter fertilizer is also unknown for a number of crops in different areas of the country. There is also a need for development and testing of fertilizer application equipment for unusual crop situations, such as hillside orchards, sugarcane, tree transplants and related crops.

While efforts in precision planting of crops in the past have not often resulted in discernible yield improvements, there is a renewed interest in

precision planting of vegetables to improve uniformity of maturation to facilitate mechanical harvesting. As needs for hand labor diminish and it becomes less available on farms, there will be an increasing need for completely automatic transplanting equipment which does not yet exist.

There is an acute need for new and improved equipment and methods for effective planing of native range grasses in the arid areas of the Southwest which will result in a greater certainty of stand. Equipment is needed which can be used to reseed relatively rough areas which are overgrown with undesirable species or have recently been cleared. There is also need for improved planting equipment and methods for forage crops in humid areas. Approximately a third of such plantings now result in poor stands and another third result in no stands at all.

In view of the foregoing needs and importance of this work, it seems that a significant increase in the research efforts to secure answers to the major unresolved questions would be in order.

Crop Harvesting and Handling Operations and Equipment

It is noted that much of this type of work is on a cooperative basis with State experiment stations. This is good as it allows specific skills and emphasis to be employed in the geographic areas where the crops are grown.

The cost of harvesting and farm handling of most crops is the major expense of production, often amounting to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

Corn is America's highest value crop. The absence of research devoted to harvesting and handling equipment and methods for this most important crop is a glaring deficiency in the USDA research program. While commercial development of shelled corn harvesting equipment has provided great increase in capacities, serious problems still exist in kernel damage and crop loss areas. Next in value comes our hay and forage crops. The application of only 1.5 professional man-years to the difficult harvesting and handling problems of these most widely grown and economically important crops is certainly not in keeping with their importance and value. Immediate steps to increase agricultural engineering research efforts for all of these crops is urgently recommended.

Due to the current status of employment of imported specialized labor forces to harvest vegetable crops, emphasis should be placed on the mechanical harvesting of these crops. It is noted that no action has taken place in this area in response to a recommendation in the last report of this Committee. If the consumer is to be supplied with wholesome fruits and vegetables in a well balanced diet, mechanical harvesting must replace the hand labor. At present, cost reduction is not the priority goal, but rather an adequate supply of these crops is more important. Immediate action on development of this specialized equipment should be given top priority.

Crop Preparation and Farm Processing

We recommend the adjustments indicated in research on crop preparation and farm processing for the handling of current problems. Problems resulting from increased capacity in harvesting machinery indicate the serious threat to crop quality which results from imbalance in system component capabilities. Both high-moisture content and crop damage at harvest contribute to additional load criteria imposed on processing, with the increased potential for crop deterioration and the development of toxic substances from certain strains of molds. It is recommended that work in this area be continued for peanuts and the oilseeds, and corn and other feed grains be cleared for toxicity of their molds.

The small input to investigations on forage is noted, together with the distribution and value of this crop. If forage harvesting-processing is to attain the stage of mechanization of our other crops, efforts must be continued and expanded in spite of past failures in achieving this goal.

The developments in improving the methods of handling burley tobacco during harvesting and curing is commended. This work should be continued.

Cotton Ginning

We commend the relative allocation of effort to the study of problems in the cotton ginning system. Improvements in methods and mechanization of handling from field to gin, and within the gin, appear to offer some of the most promising opportunities for improvements in efficiency and cost reduction in this sub-system.

Air pollution by gin dust and by trash burners certainly deserves increased research effort. Until study of the effects of burning undegraded pesticide residues carried by trash has been made, the potential of this contaminant in the smoke is unknown. Both the dust and smoke contribute to a seasonal type of air pollution most acute in good weather when atmospheric turbulence may be inadequate for dilution and dispersion.

Improvements in bale packaging with appropriate continuous sampling would seem to require engineering assistance in the use of equipment and labor in handling and marketing. The feedback to the ginning system is improvement in baling capacity with decreased labor as this operation also adjusts to take the capacity of high-speed gins.

Structures for Crop and Machinery Storage and Plant Growth

Work on plant growth structures needed for research in other disciplines should be continued. Greater precision in environmental control and uniformity of conditions in all parts of growth chambers is needed for the most refined experiments. Additional information is needed about conditions desirable for studies with different specimens or objectives.

Recommendations have been made for further studies in mechanical handling of forage crops from the larger crop storage structures directly into livestock feeding systems. No progress has been reported in this area. The previous recommendation for increased work in this area is repeated, with emphasis on materials handling.

Close coordination of the work on structural materials and construction methods should be maintained with the various states. New materials are continually appearing on the market which need to be evaluated for farm use and this work should be continued.

Livestock Engineering (Except Electrical)

This needs special emphasis since it is reported to relate to a large investment of $14 billion in service buildings and related structural equipment and since there is an annual maintenance and new additions cost of $1.2 billion, over half of which is for livestock facilities. The lack of emphasis in the extremely important livestock engineering area of research, other than poultry is again noted. Existing research needs to be strengthened and expanded. The livestock producer needs improved structures and equipment to gain greater efficiency. As pointed out later, he needs special help in the disposal of animal wastes. Since this phase is so integrated with production, the Committee again recommends an increase in the program in the coming year. When new poultry research laboratories are completed and staffed, the engineering research effort on poultry should be adequate for the present.

Farm Waste Disposal and Farmstead Water Supplies

Time has only increased the urgent need for greatly expanding the work on farm waste disposal.

The urgency of work on farm wastes has been emphasized by the Committee the last two years. This lapse of time has only served to emphasize the severity and immediate need for greatly expanding research to develop new techniques and methods which will adequately handle this problem. We strongly urge that work on farm waste disposal be adequately expanded in both personnel and facilities. Personnel from all disciplines necessary to adequately handle the work should be provided to carry the work to a rapid and satisfactory conclusion. The satisfactory handling of organic wastes, dusts, odors and smoke should be considered a part of this work.

Reference to the quality of water has been made earlier. Pure water is a basic farmstead requirement--large quantities are required for human use, livestock operations, crop cleaning and processing, and other uses. These water requirements are continually expanding with ever increasing sources of water contamination. Work should be started at once to determine ways and means of insuring adequate supplies of pure water for farm use. These studies should include the development of methods for effectively and economically treating water to insure its safe use where natural sources of pure water are not available. These recommendations concur with those made by the National Agricultural Research Advisory Committee in its 1965 report.

Electric Equipment for Farm Labor Reduction

American agriculture produces about 600 million tons of crop and animal products each year. This is more than five times the weight of the total annual steel production in the United States. Most of these products are handled several times, which means a tremendous task of moving material.

Development of equipment to decrease labor of livestock chores has been far less rapid than development of field equipment. For example, the production per man-hour for all crops incrased an estimated 463 percent during the last 50 years. This increase is more than twice that for all livestock, 227 percent. The amount of working time spent on livestock other than horses and mules (estimated to be 3,282 million man-hours per year in 1964) is 39 percent of the entire farm labor requirement. Because livestock chore equipment may be needed 365 days per year, it must be more reliable in operation than field equipment which may be used only a few days per year.

Equipment to stubstitute electric energy or tractor power for hand labor for many farmstead operations is now on the market, but research is needed to provide flexibility of use in existing buildings and to permit automatic control as well as to extend mechanization to other operations. Increased emphasis on automatic materials handling equipment by livestock producers and equipment manufacturers has caused them to obtain the advice and counsel of research workers. A continuing aggressive research program is essential to meet the developing needs of this segment of our national economy.

In view of the great and urgent need for labor and cost reduction in the farmstead area, the allocation of only 4.5 professional man-years to USDA research in this field appears woefully inadequate and particularly so in the field of livestock equipment which receives only 2.0 professional man-years of effort. Because the application of electric power to replace human effort appears to offer such promising potential here, a doubling and even redoubling of research effort in this area would appear readily justified and is strongly recommended.

Farm Electrification

It appears that studies of farm electric service and research instrumentation have been adjusted so that the effectiveness of all other areas can be improved through the application of appropriate instrumentation. For this, we offer commendation, and encourage the further application of instrumentation to the degree of sophistication indicated for the production of data of the reliability required.

In line with an agreement that the Agricultural Research Service will conduct research for the Rural Electrification Administration, we believe that further service studies on energy distribution and demand should be defined and developed, for the economic advantage of farm utilization of electric power which could result.

Work should be conducted with heat pumps in connection with milk cooling to investigate the possibility of utilizing the available energy on larger dairy farms for home heating.

Since more crops are being produced in controlled environments, inexpensive equipment to produce these conditions is essential. Work should be continued in this area.

The work on mechanical equipment for apiaries should be continued. While sales from this segment of agricultural production are small, the bee industry will affect some of the larger segments of crop production where natural pollination is a limiting factor until a satisfactory alternative is found. No expansion of this activity is indicated, but it is suggested that this modest support provides the most economical one in meeting the national interest of other areas of agriculture affected.

Rural Dwellings

The work of developing sound, economic designs and planning guides for housing migratory farm workers should be continued as demands and conditions warrant. It is recommended that the work on farm homes and rural dwellings be continued at the same level. Major emphasis should be placed on functional design requirements and recommendations. This should include keeping up with new materials and construction techniques.

PROTECTION OF PLANTS AND ANIMALS

Crop Pest Control Techniques and Equipment

In view of the great economic impact of weed, insect and disease damage to agriculture and also the public interest involved in minimizing chemical and other residues and contamination of soil, air, water and plant life, this work is of utmost importance and the programs underway should be pursued with diligence. For these same reasons, research with nonchemical methods of control and the equipment needs for their utilization should also be vigorously carried out.

Physical Methods of Insect Control

The work on electromagnetic and ultrasonic energy for insect control and the treatment of seeds and plant products is commended. It is recommended that the present work be continued to determine how effective such methods of controlling various insects can be. Where light traps are not found to be an adequate control by themselves, this method of monitoring infestations so that chemical or other control treatments can be reduced to a minimum should be studied and evaluated. This work should be expanded in cooperation with entomologists to determine its value for controlling economic insects or for determining emergence or population densities as a guide to insecticide treatment.

The work to determine the wave lengths of radiation or other stimuli which will give the maximum attraction to different insect species should be continued at a rate needed to supplement the actual trap studies. The work on electromagnetic radiation as a method for controlling insects in seeds and plant products should be continued at present levels.

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Dr. G. L. Mehren, Assistant Secretary and Director of Science and Education, is Chairman of the Committee; Dr. H. A. Rodenhiser, Deputy Administrator for Farm Research, Agricultural Research Service, is Vice Chairman.

John D. Wells was unable to attend the meeting.

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COMMENTS AND RECOMMENDATIONS

GENERAL

Major changes have occurred in supplies of commodities and the availability of labor at a time when domestic and world populations have reached unprecedented proportions requiring urgent attention from the standpoint of food supply.

Such a challenge signals a renewed emphasis in the agricultural revolution which began 25 years ago.

Agriculture has a clear responsibility to maintain the current high standard of living of our own people while maintaining safe commodity reserves for emergency needs, and to assist in supplying some of the world food requirements in countries which do not now have the resources to provide for themselves. In order to most effectively accomplish the latter, the Department should develop a permanent program for foreign adaptive research. It should seek to obtain the necessary increases in staff to operate this program.

It is essential for agricultural science to maintain and expand a broadly based research program to gain new knowledge and meet current and future problems. In order to do this, agricultural leaders must take the necessary steps to improve the public image of this work -- to more effectively relate the story of its broad significance for individuals, the Nation and the World.

In addition to emphasis on production of food and fiber, agriculture must be concerned with many other things affecting our national well-being. For example, the quality of our environment must be protected so that we may develop, conserve, and use the nation's human, land, air, and water resources in accord with present and future needs. The Committee strongly recommends that researchers experienced in all aspects of agriculture participate in study and action programs involving the quality of water, air, and soil and other elements of the environment.

As a major user of water, agriculture has a responsibility to make the most efficient use of any water supplies which are or can be made available. Optimum utilization requires basic and applied research to achieve development of improved application practices, to develop improved lower-water consuming crops, and to make possible the use of relatively low quality water supplies.

Shortage of manpower to operate the agricultural industry to full capacity brings into sharp focus the absolute necessity to mechanize, on a systematic basis, as many operations as can logically be performed by machines. Without improved efficiency of operation, consumer costs of agricultural produce, at the farm, will have no alternative but to rise. In

order to be competitive for manpower, ways must be found to make farm labor productive enough to warrant pay comparable to that in other types of work. Further and improved mechanization is required to do this. It should be keyed to machine capabilities rather than to mere replacement of men and horses.

Improved efficiency of operation means better yields of agricultural commodities, economically grown, harvested, transported, and stored -- none of which occurs by chance. Careful cooperative research, analysis and dissemination of findings remain the foundation of agricultural progress, in keeping with the demands of the times.

Important steps were taken in 1966 with the publishing of "A Ten Year Program of Federal Water Resources Research" by the Office of Science and Technology, Executive Office of the President (February 1966) and "A National Program of Research for Agriculture" by the Association of State Universities and Land Grant Colleges and the U.S. Department of Agriculture (October 1966). This Committee believes that these publications and "Facility Needs--Soil and Water Conservation," Committee on Appropriations, U.S. Senate (Document No. 59, 86th Congress) 1959, provide excellent guidelines for research and research facilities needed in the agriculture if it is to meet national goals. Study indicates that further effort is necessary to make the recommendations of these documents fully compatible and operational.

The Committee strongly recommends that the Department, particularly the Agricultural Research Service, further program many major lines of research on a systems approach, utilizing interdisciplinary and interagency capabilities. The state of the art in the production of food and fiber has attained a level that certain areas and certain types of operating units require more sophisticated means for effective management and control than can be obtained from mental analog. In general, this requires that some combination of the techniques of operations research, systems analysis, engineering economy, and the like, be developed and applied, so that the system can be modeled and data generated for decision making and prediction. This development for crop and animal production systems is particularly attractive due to its potential use by those immediately concerned.

Persons responsible for administration and control of items of related research and development would benefit from production systems modeling because the model would specify the type and kind of systems input to be expected from the application of results of research. It would orient the research worker to the specific kind of contribution his effort would provide within the total system. To the grower, the model would represent a more effective tool for generating alternatives for his decision problems. At least these three groups should benefit directly from production systems modeling and analysis.

The Committee recommends that greater use be made of scientists and knowledge available within existing USDA cooperative research programs (across organizational and discipline lines) for planning and executing various programs including those with other public and private research organizations.

USDA programs for making grants or contracts with universities and colleges for cooperative research work encourage advance training of scientists, thus assuring that professional research and education personnel will be adequately trained to more nearly meet program requirements.

Basic research, as differentiated from applied and developmental research, has been described in "A National Program of Research for Agriculture" as having the potential ". . . . to enhance the national capacity to develop and disseminate new knowledge and new or improved methodology for solving current problems or new problems that will arise in the future." The report estimates that approximately 40 per cent of USDA research is basic, with an upward trend in the future. The Committee supports this direction of emphasis in the realization that there are still too many fundamental unknown factors in the nature and idiosyncrasy of biological phenomena to make full use of the other areas of research dependent on this knowledge.

Again, we have been impressed with the dedication, the sincerity and the capabilities of the leadership in Farm Research and the Divisions reviewed. The handling of the complexities of the problems of research, the loyalty of staff, and participation in multidisciplinary developments in the attack of problems conceived as system inputs are especially commended.

However, disappointment is expressed that some 10 per cent of professional positions remain unfilled, apparently due to the supply-demand situation and the level of starting salary. If appropriate adjustment could be made on the basis of the critical nature of the work and supply of trained personnel for filling these positions, some relief would be provided. Suggestions and recommendations for meeting this need for professional personnel are:

1. Improve starting salary rate for agricultural engineers and scientists with advanced degrees. It is reported that the National Aeronautics and Space Administration was authorized to raise salary rates one grade over the regular Civil Service classifications in view of their critical need for engineering and scientific personnel. As the need for research agricultural engineers also appears to be extremely critical and in view of the vital importance of agricultural engineering efforts in modern mechanized agriculture, it seems logical that similar authorization be given to raise agricultural engineering salary rates.

2. In cooperation with the American Society of Agricultural Engineers' personnel service and similar units in other scientific societies, set up a special recruitment program to induce more agricultural engineers and scientists to accept USDA research positions.

That this situation may become worse before it can be corrected is indicated from the change in conditions in the very short period since the conception of objectives whch led to the development of the National Program of Research for Agriculture. Agricultural engineering is included in the detailing of 20 problem areas. At the same time, projections of most agricultural

engineering participation is detailed as remaining at or near the 1965 level throughout the period of the projection. If machine applications required by the agriculture industry implement adoption of results of research of other disciplines developed within the projected period, the allocations for engineering research in the initial report require reevaluation.

The Committee again emphasizes the inadequate support for agricultural engineering research and strongly recommends substantial expansion of support for this work.

To meet the urgent demands for the mechanization of all phases of agriculture, extra support and emphasis must be given to agricultural engineering research to insure the needed supplies of food and fiber. With the increasing shortages of farm labor, the production of many crops will have to be curtailed or abandoned as economically unfeasible unless the production and harvesting can be mechanized.

The research needed to develop the techniques and the resulting equipment to perform these jobs in many cases cannot be expected from industry. The research and development costs are so great in comparison to the limited numbers of machines needed that these costs cannot be recovered by industry. Even where industry and/or the States are working on phases of these problems, support from the Federal level should be available to coordinate and assist with these developments. In many cases there are possibilities of extending the findings to meet other problems in another area. Vegetable, fruit, and nut harvesting are examples.

The 1966 report of the National Agricultural Research Advisory Committee stated "It also is apparent that one of the road blocks to carrying out agricultural engineering research is the lack of both the number of qualified agricultural engineers available and the opportunities for retraining present agricultural engineers to meet current requirements in this field. The Committee recommends that a very high priority be given to this program."

Thus, the Farm Resources and Facilities Research Advisory Committee recommends that agricultural engineering research, as well as cooperative research with other related agricultural research programs, be expanded to where the emphasis will be comparable to that for other types of agricultural research.

Because of the overall importance of grain row crops in agriculture, the Committee recommends that a separate research center or laboratory be established for coordinating, handling and carrying out research programs involved in the development of effective systems for the production of grain row crops, including the related farm transport, storage and utilization aspects. This recommendation is made for the following major reasons:

1. The combined farm value of three of the principal crops in this group--corn, soybeans and grain sorghums--represents over one-third of the total farm value of all agricultural crops. No other crop

even approaches the value of our corn crop and there is no other related group of crops that produces as much as a major fraction of the value of this crop to the American economy.

2. This important area appears neglected in the National Program of Research for Agriculture. For example, the problem area on Mechanization of Forage Crops, which we assume to include row crops used for forage, is one of the few areas for which no increase is recommended. Though a related problem area, Systems Analysis in Production of Field Crops, has a projected 108 percent increase by 1972, the actual effort will still only represent a total of 25 scientific man-years--an almost insignificant amount when compared to the 1130 scientific man-years recommended for the area, Improvement of Biological Efficiency of Field Crops. Obviously, it could be pointless to develop improved varieties if they cannot be harvested efficiently under future conditions of limited manpower availability.

3. The critical needs of this vital area will be emphasized if the work is at one location.

4. Improved coordination and, thus, improved effectiveness will result from establishment of such a headquarters center for correlating these research efforts.

5. Equipment needs, tillage practices, harvesting operations and production systems for the grain row crops are interrelated with many of the same or similar machines, operations and practices being utilized for several of the crops involved. Also, two or more of these crops are often produced by the same farmer.

CONSERVATION, DEVELOPMENT AND USE OF SOIL, WATER AND RELATED RESOURCES

Natural Resource Economics

Steps should be taken to integrate the research work of the Natural Resource Economics Division of the Economic Research Service with that of the Soil and Water and Agricultural Engineering Research Divisions of the Agricultural Research Service. Although demands for the services of the Natural Resource Economics Division are great, the Committee recommends that this Division effectively participate in a well-balanced program of both basic and applied research with Agricultural Research Service and related programs.

In keeping with the recommendations of "A National Program of Research for Agriculture," the Division is encouraged to maintain its support of the following basic research areas:

1. Integrated economic models for decision making
2. Prediction of farmer response to various economic forces
3. Improvement of techniques for the collection of economic data
4. Determination of the controlling factors in economic development

A significant development in any of the above areas of study would contribute substantially to a solution of applied problems in the natural resources field.

It is noted with gratification that a national inventory of major uses of land will soon be completed and statistics published. With this benchmark information at hand, it would seem logical next to pursue an economic study of recommended land use patterns, nationally, for the most efficient production of agricultural commodities. A national land policy is needed to guide shifts in agricultural production and to provide a framework for the wise selection of alternative land resource development projects.

Deserving of special recognition are the studies which have been made of the economics of water utilization and watershed development and those pertaining to the problems of water rights and water legislation. Both study areas contain problems which are of vital concern to the rural economy.

Much additional research is needed to accurately and adequately define the role of land and water resources in the national economy. We recommend the utilization of regional appraisal techniques to more fully assess the economic impacts of trial resource conservation and development programs, and the use of these same techniques wherever possible to develop improved methods of benefit-cost analysis for land and water development projects.

Recognizing that land resource development programs play an important role in the rejuvenation of depressed economies, it is recommended that studies of the income distribution effects of natural resource improvement projects be continued and that interregional comparisons of these effects be made. Such studies are needed to help realize improved income opportunities in rural communities. Depending on sources of funds and personnel available, it may be desirable to reduce the scientific man-years devoted to some other activity rather than this one during the forthcoming fiscal year. Recommended for the reduction, if it is necessary, would be some activity which is less basic in nature.

Due to the urgency of the work in the field of farm and industrial wastes and the relationship of these wastes to natural resource pollution, it is strongly recommended that an aggressive research program be undertaken into the social and economic ramifications of waste management and control in relation to the agricultural and rural environment.

Water and Related Land Resources

It should be stressed that everything man has and does is related to the land and water resources of our great Nation. It is imperative that the competitive uses for water in connection with land resources receive very careful study to provide economical, just, and logical development to meet man's present and future needs. This includes the following emphasis of effort:

Sedimentation

It is recognized that a strong program of sedimentation research has been and is now being carried forth by the Department of Agriculture. The more recent awareness and relationship of sedimentation as it applies to the water quality problem indicates the importance of added emphasis and work in this field. Agricultural research has a capability of experience and facilities in this type of research. It will be desirable and beneficial to utilize and expand the effort of sedimentation research cooperatively with other agencies of government that are now actively concerned with water pollution problems.

Hydrology

The hydrologic research of the Soil and Water Conservation Research Division appears to be directed to solving pertinent problems, which is commendable. Hydrologic research involves many different types of terrain and climatic variations and here again it appears the watershed studies now being developed and in progress give a reasonable coverage to the variations to be expected. It is reiterated that specific program increases are needed in problems associated with groundwater use and groundwater recharge. The Committee strongly recommends that research be instituted to identify paths of water and its movement in a full water use system. This will require study of deep percolation, seepage, contamination, groundwater use, reuse and recharge--all as related to the most efficient use of water and land on a basin wide or unit area basis. Another fruitful area for conducting research appears to be in hydrologic measurement instrumentation.

With the other programs of hydrologic research being developed in such agencies as the Weather Bureau, the Interior Department, and universities (under P.L. 88-379, the Water Resources Research Act of 1964), it is recognized that the experimental watershed experience of the Department of Agriculture should be called upon for wise use of funds, facilities, and information. The Committee on Water Resources Research of the Office of Science and Technology provides a means for proper coordination and cooperation in this respect. Due recognition should be given the International Hydrological Decade program by full interchange of research findings. Exchange of foreign personnel might also be considered.

There is an urgent need for trained professional people in hydrologic research, so the need for utmost cooperation with university programs is stressed.

Conservation of Water and Irrigation Practices

With the fact that agriculture is a major user of water in the consumptive sense, it is important that research on efficiency of water in conveyance, on-the-farm use and care in water disposal should be receiving a major effort. The report of the Federal Council for Science and Technology entitled "A Ten-Year Program of Federal Water Resources Research" calls for accelerated effort in this category. This recommendation should be given due consideration by administrators and professional workers alike. Since education of

water users is involved, there is need for research on how to get acceptance of already known information on conservation practices that may be applied. Research on the use or reuse of poorer quality water should get more attention than it appears to be getting if greatest conservation of our present resources is to be achieved.

Drainage

Excess water is an agricultural problem on millions of acres in the United States, a major portion of which are cropped. Since only a small percentage of this wet land has been properly drained, the future will witness a great need for much more agricultural drainage to help satisfy the demand for more fertile acres. The more easy-to-drain lands are generally treated first, leaving the more difficult-do-drain lands, with their many problems, as yet to be satisfactorily handled.

Since adequate information is lacking for the proper design of many agricultural drainage conditions, it is essential that research efforts be continued, and increased where possible, for surface and subsurface agricultural drainage.

Basic and applied research should be increased in the following areas: (1) water tolerance of plants, (2) drainage coefficients for different crops, (3) depth and spacing of tile for different soils and crops, (4) drainage materials, (5) methods of installation and construction of drainage systems, (6) drain tile open inlets, (7) hydraulic characteristics, (8) special structures, (9) side-hill seepage, (10) economic analyses utilizing a systems approach, and (11) determinants for and the impacts of subterranean translocation of water.

Wind and Water Erosion

The national emphasis on improving the quality of our environment is directly concerned with wind erosion. Resulting dust problems make it important to give them attention and provide for coordination of research on this subject with other agencies concerned with air pollution. Basic research is needed on wind phenomena as they relate to agricultural practices and agricultural terrain. This should be a part of a general research effort on the impact of weather modification on agriculture--this research to encompass studies of such things as soil-plant relations and energy interchange factors between plants, soils, the surrounding microenvironment and the atmosphere.

The present Department program and facilities for erosion studies on agricultural land appear to be offering a reasonable level of research activity. A specific example is the study being undertaken to develop a reliable equation for estimating soil losses under variable conditions and locations. Caution should be given to considering research problems concerned with bringing in to use new crop lands that have steeper slopes and different soil conditions.

Moisture Conservation

It is noted that this is one area in which a shifting of program effort was effected in 1966, resulting in termination of some existing studies. We commend the Department for this analysis and upgrading of its program.

Soil Properties and Management

The physical and chemical properties of soils greatly influence plant growth because of their modifying effects on root penetration, microbial activity, water and air supply, and the occurrence or absence of other growth influencing factors. It is important for efficient use of soils to be able to recognize and measure those properties of major significance to farm, range, and forest production. Such basic information becomes the foundation not only for improving farm and ranch cropping practices and the efficiency of these business operations, but also for soil interpretations and classifications which aid in rural land use planning. Guidelines are needed to help identify soil areas which are well adapted to different land uses in developing economies.

The Committee recommends a more aggressive and expanded research program, with particular reference to the following:

1. Identifying those properties, such as soil structure, which significantly affect plant growth and the translocation of soil water and developing useful methods to measure these properties.

2. Modifying soil profiles to improve unfavorable conditions for root growth.

3. Determining, with active participation of cooperating scientists, the adaptation of crop varieties to production constraints imposed by a range of soil physical and chemical properties and management practices.

4. Determining the effects of soil physical and chemical properties on the persistence, degradation and movement of those pesticides that might result in a pollution problem.

5. Determining the possibility of using remote sensing as a means of identifying and recording general soil properties.

Soil Machine Relationships

We commend the National Tillage Machinery Laboratory for its excellent cooperation with industry and with other disciplines in providing immediate information leading to application of test results and basic research related to tires and tillage tools. Since tillage operations are responsible for such a large proportion of crop production costs, even small improvements in functional performance of tools and traction elements have an important effect on cost control. This, and related work at other locations as well,

should be continued to assure developments which meet the requirements of growers in adapting machine systems to the changing needs in cultural practices suitable for special crops and conservation farming.

Soil - Water - Plant Relationships

Continuing pressure on the natural water supply of the Nation makes it mandatory that every effort be expended to conserve the quantity and quality available for varying needs.

It has been estimated that 70 percent of the entire water budget is used in the process of evapotranspiration from the soil reservoir, yet there is far too little understanding of the phenomena of water movement through various soil types, into and through different plant species, and under varying meteorological conditions. For example, it is known that certain plants or varieties withstand saline conditions where others do not, utilize different levels of nutrients to advantage and others do not, and transpire inordinate volumes of soil moisture without any beneficial use being made of most of it. It is also known that air and soil temperatures affect plants differently at different levels; less than 2 percent of the sun's energy is converted into plant material; and reduced photosynthesis reduces the efficiency with which water is used by plants. While all these are known, there is too little basic understanding of the interplay of the determining factors in the root zone as well as in the leaf area.

Rationing of water of reduced quality in the future may indicate the use of impaired water for production of food and fiber. To what extent will this water move through soils and plants and with what effect on food supplies? What effect does air pollution have on various plants? Answers to these questions and others like them have a direct bearing on the related fields of moisture conservation, soil management, irrigation, drainage, and waste disposal, with overriding significance in the task of feeding a growing population on a dwindling acreage.

The long range study of agricultural research undertaken at the recommendation of the U.S. Senate Committee on Agricultural Appropriations has given first-place mention to "The physical, chemical, and biological characteristics and energy relationships of the soil-water-plant-atmosphere environment" in its list of basic research needs.

It is thus the recommendation of this Committee that this important area of research be coordinated within an adequate facility, as called for in Senate Document 59, and that greater emphasis be given to this important field of research immediately. It is further recommended that concentrated attention be given to the various ways of decreasing evapotranspiration losses, increasing the storage of water in the root zone, and increasing the efficiency of water use by economic crops in order to stretch existing supplies.

Saline, Sodic, and Related Soils Problems

Excessive salt and sodium problems are typical of soils in arid and semiarid regions. From the beginning of time, drainage and runoff from the land have put some salt into groundwater and surface streams. Down-river irrigation waters gradually increase in content of inorganic salts. Permanent and productive agriculture requires that excessive amounts of salt and/or sodium not be allowed to accumulate in a soil profile, or any part of the root zone.

Maintenance of safe limits of salt and sodium in a soil requires drainage, and at least some leaching. Present research programs to accomplish reclamation of salt affected soils more effectively and efficiently should be continued at the present level. Because agriculture will of necessity have to use lower quality of water in the future, the Committee recommends that research be intensified to determine:

1. How to utilize water of lower quality for irrigation, yet not increase the salt in the soil or significantly in streams (techniques of handling drainage water).

2. More accurate criteria than presently available on which to classify water, including streams, in terms of quality for irrigation.

3. The mechanisms of salt tolerances of plants, and in cooperation with plant breeders, select or develop varieties of economic crops having high salt tolerance.

Nutrient Requirements and Use by Plants

A major objective of agricultural research is to provide an adequate future supply of farm products for domestic and foreign consumption. To accomplish this goal, it will be necessary to increase yields and quality of food per unit area of land. This must be done at decreasing real production costs. Furthermore, careful management of natural resources will be needed to avoid deterioration of the soil and surrounding environment.

It is recognized that the use of fertilizers is a prime consideration for efficient production of an ample supply of quality foods. However, much of the knowledge is incomplete and qualitative in nature, and research is falling behind insofar as quantitative aspects are concerned. Rather recent studies have demonstrated the need, under certain conditions, for micro- and secondary nutrient elements and the interactions between these nutrients and the major elements. The full implications of this knowledge are far from being clear and confusion exists.

Variations in nutrient requirements of some crop varieties, including specific hybrids, have been found in some cases in relation both to yield and quality, but the information is incomplete. In addition, plant nutritional requirements are known to be influenced by a host of other variables such as soil type, moisture stress, temperature, etc. These examples alone indicate the

need for additional definitive knowledge to clarify these findings so that they can be put to use in effective systems of management.

The problem of efficient fertilization is not simple and is further confounded by several considerations. It is well known that a large part of the chemical fertilizer applied to the soil is not taken up by plants. This can reduce the economic efficiency of the operation and leave the excess in the soil which can accumulate to high levels or be leached below the root zone (as nitrate) and perhaps into the groundwater as a contaminate. A November 1965 President's Science Advisory Committee report on "Restoring the Quality of the Environment" includes the following:

> "A number of elements other than nitrogen, phosphorus and potassium are used as fertilizers. These substances are applied in agricultural practice to correct plant deficiencies arising from the low available levels in the soil of these micronutrients. Iron, copper, manganese, and molybdenum, for example, are, or have been, used in this way in a number of regions. Where the treatment is made properly and the appropriate rates of application are employed, there are no undesirable effects on plants. Occasionally, however, excessive quantities of these fertilizing elements have been applied to soil; abnormal and stunted plants have resulted; and crop yields and quality have been reduced."

Little information is available as to possible deleterious effects of excessive accumulation of certain elements, such as some of the micronutrients or contaminates in fertilizer on plant growth or on animals utilizing feed grown under such conditions.

Because of the reduced research in this area in the past few years, it is felt that research efforts should be increased so that knowledge falls no further behind. Such information is critical, not only to the producer but to the formulator of fertilizer materials.

It is recommended that additional research be implemented to determine in a quantitative way:

1. Nutrient activity in soils; chemical changes of nutrient elements in different soils; and factors affecting the movement of nutrients and their availability, uptake and interactions in order to improve the biological efficiency of crop plants (basic studies).

2. The useful amount of macro- and micronutrients in a given soil at a given time throughout the root zone (diagnosis).

3. The kinds, amounts, and placement of nutrients needed in specific soils by the common species and varieties of food and fiber crops for maximum yield and quality, as well as yield and quality for maximum economic return under alternative management systems (application).

Nutrition of Animals Affected by Properties and Characteristics of Soils and Plants

No soil-plant research is complete without the important inclusion of studies of animal utilization of the plant materials in body metabolism. An example of what can be done in this important phase of agricultural research is represented by the important strides that have been made very recently in the identification of basic life processes at the U.S. Plant, Soil and Nutrition Laboratory.

Emphasis should continue to be placed on a study of the pathways followed by micronutrients from soil to plants to animals. Such study should include the interactions of micro- and macronutrients at all stages along the food chain.

Remote Sensing (By Photographic and Other Means)

The Committee was impressed with the progress which has been made in this area. When it was first brought to our attention about three years ago, it seemed to show promise, but there was no indication of the potential which has been uncovered.

We commend the pursuit of this activity in its several areas for further developments which may be used in the coordination of disease and pest control; detection of soil and salinity problems; monitoring of soils, crops, and animals; and other exciting and practical applications. It is recommended that this breakthrough in a useful technique be exploited as rapidly as possible, and it is hoped that further spinoff from NASA developments can be applied by USDA scientists and engineers.

EFFICIENT PRODUCTION AND QUALITY IMPROVEMENT

Planting and Fertilizer Operations and Equipment

In this activity, it appears that adequate weight is being given to planting and placement of fertilizers in normal soil types in plants--the common grain and cotton crops. It is assumed that work will continue to determine the best planting geometry for various crops in the more unusual soil types and various parts of the country.

It is the observation and feeling of the Committee that more emphasis should be given to vegetable crops in reference to the new varieties being developed for adaptation to mechanical harvesting. This is a must in terms of the immediate and future absence of adequate hand labor as well as the economic factor involved even if labor was available. The development of automatic equipment is urgent for both planting and transplanting.

Proper recognition must be made to incorporate all the advantages that are possible in "minimum tillage" operations which are now being used in many areas.

Grassland restoration and brush control continues to require attention on vast acreages. The need for work to continue in the planting of forage and range crops is important, especially in the once-over method in reseeding range areas. These machines should also incorporate the application of herbicides.

In research on anhydrous ammonia, studies need to be conducted to find ways to prevent loss by escape of gases by improper location of placement in various soil types and in relation to root zones of all crops, especially row crops. This research must be both on machines for specific application of anhydrous ammonia and those for planting equipment where placement is part of the once-over operation.

Crop Harvesting and Handling Operations and Equipment

The prime example of the imbalance between agricultural engineering and other inputs to research on crops is shown in this area. There are 24 scientific man-years spread across nine general crop groupings, most of which have three or more subareas by specific crop. This seems to result in "mechanization" of harvest and handling operations in an attempt to duplicate man-methods. This approach appears to produce special machine capabilities provided by enormously greater power combined with reduced dexterity. The result is complex and expensive machines that are tolerated only because no suitable alternative is offered. Cost reduction is asked for, but in the same breath, faster and more powerful machines--with the hope that they shall do no injury to the harvested product.

It is suggested that this area should receive administrative study and that the workers be encouraged to analyze the systems approach in lieu of seeking refinements in machine components to improve the "mechanization" of man-methods in the harvesting machines.

An example of the systems approach is furnished by the cooperative USDA-Texas A&M efforts at Lubbock, Texas, in the concurrent development of a crop production system concept for the area. This included a machine and a compatible plant as the principal ingredients in a low-cost, high yield system for quality cotton. The plant was designed by the plant breeders to accept most of the effects and interrelationships between the variables in the environment/plant/machine system.

Equipment, Methods and Systems for
Harvesting and Processing Forage Crops

Hay and forage crops are the most widely grown (approximately 85 million acres) of any crops in the United States and outrank all other crops except corn value. Extreme problems still exist in the harvesting of hay, with total

preventable loss of the hay crop in 1962 estimated at 21 percent. This would readily appear to provide the greatest potential for immediate return of any single agricultural research area.

In the face of this vast need and huge potential return, it cannot be understood why only 0.8 scientific man-years of research effort is planned this year in this important area, with no increase planned for next year. It is most strongly recommended that this effort be multiplied at least ten-fold as rapidly as programs can be worked out and men transferred to this area.

Improvement of Corn Harvesting Operations and Equipment

Corn is still America's highest value crop by a wide margin. Through previous efforts of crop scientists and agricultural engineers in both public research and private industry, the yield and value of this crop has been greatly increased while mechanization has steadily reduced the man-hours required per unit.

However, problems still exist with kernel damage and other losses in corn harvesting operations. In view of the past success, it is logical to expect that these problems could be solved by USDA agricultural engineers and scientists with a relatively modest investment of research funds and effort--considering the tremendous savings possible. Last year it was recommended that this glaring deficiency in the USDA research program be rectified, but no work has been done and there was no reference to any planned for the future. It is again recommended that an agricultural engineering research program be established as promptly as possible to improve methods and reduce losses in corn harvesting.

Vegetable, Fruit and Nut Crop Harvesting

The other obvious blank area in harvesting operations and equipment research is that for our vegetable, fruit and nut crops. With many of these crops, harvesting constitutes the most costly operation and requires the greatest number of man hours expended for the overall production outlay. Moreover, as has been shown in many instances, if plant characteristics and growing habits necessary for successful mechanical harvesting are known, plant breeders can often meet these requirements. Such advancement can only be gained by close mutual cooperation and investigation between these and other groups.

A rather substantial program on vegetable, fruit and nut harvesting research is needed in light of the increasing costs and scarcity of hand labor. We commend the progress made in harvesting and handling fruits and vegetables for processing. However, the capabilities of these machines to damage the product preclude their use for fresh market use. The inference may be drawn that new concepts for the systems approach developed from more exhaustive analysis of machine requirements may provide the breakthrough in basic principle required in these areas. While a substantial amount of work should be directed to completely mechanizing the harvesting procedures for all types

of processing vegetables, major effort should be devoted to fundamental studies of methods for mechanical detachment, separation, and conveying of vegetables, fruits and nuts to serve as a basis for applied research on harvesting them for fresh market use.

In further support of these recommendations, it is noted that the National Program of Research for Agriculture also recommends a 114 percent increase in research on mechanization of fruit and vegetable crop production in the next five years.

Crop Preparation and Farm Processing (Except Cotton)

The problems here are concerned with the development of better methods. Techniques and equipment for use on farms for the initial preparation for market or the processing of farm products to increase efficiency in labor and equipment and to preserve quality and prevent spoilage and damage from mechanical handling are very important.

Fruits and Vegetables

The items listed above are particularly large factors in farm preparation and processing of fruits and vegetables, especially the perishable class.

More emphasis should be devoted to reducing mechanical damage in preparation, and changes in quality due to processing at the farm level. Many freshly harvested agricultural crops must be given early treatment in order to maintain original quality of flavor, texture, color and appearance. More information is needed on pre- and post-storage treatment of potatoes, including damage due to mechanical handling in hydra-flow systems. More information is needed on the effects of washing and additives in the washing medium to preserve keeping qualities and to guard against any health hazards to consumers.

Packaging and processing for the demanding consumer is becoming evermore complicated. Packaging to promote appearance and selling is not always consistent with preservation of quality and condition of the product from producer through to consumer. More study and research is needed in the problem of on-the-farm storage, packing and processing versus on-the-farm storage and central packing and processing versus central storage packing and processing.

The aforesaid will require work on containers, transportation and handling equipment, protection from temperature damages, and time studies.

Seed Cleaning

Seed cleaning appears to be receiving adequate attention with recommended testing and development of the centrifugal screen separator. This holds hope for increased machine capacity and efficiency, resulting in economies.

Tobacco Curing

The research in this area indicates a trend toward structures affording more controlled atmospheric conditions with the possibility of additives or exclusions in the air. Studies have indicated the possibility of reduced spacing and lower overall space requirements. In the curing of primed burley tobacco it appears that more environmental control will enable farmers to cure tobacco independent of fluctuating weather conditions. This appears to have promise and work should be continued.

Grain Drying

The work being done at Ames, Iowa, and viewed by this Committee last year, is important and commendable. The rapid acceptance of field shelling of corn prompts continued emphasis on all phases of drying with special attention to design of equipment for increased capacity and efficiency. Effects of mechanical damage, both the damage incurred during the shelling and that during the drying process, are extremely important. The time limitation on storing grain is dictated by deterioration caused by molds and respiration, and mechanical damage is the opening to this process of decay. Continuing research is recommended.

Forage Processing

Work in this area is weak showing no information on the principal hay crops of the main areas except Coastal Bermuda grass and millet. Extensive research needs to be carried on for alfalfa, clovers, brome, fescues and other hay crops. Special emphasis should be given to weight and volume reduction as well as to the size of pieces best suited to mechanical automatic feeding.

Cotton Ginning

We commend the relative allocation of effort to the search for solutions to some of the urgent problems in this stage of the production of cotton. While materials handling has continued to pose problems, implementation of practices which foster quality fiber indicate that more determinant plant growth and a shorter harvest period will impose a need for a greater storage capacity for seed cotton at gins. Information enhancing the capabilities of gins to meet this new problem or, as an alternative, to adapt to farm storage will expedite a solution to the problem of movement of the crop from harvesting to the first stage of processing.

We commend the work in air handling systems at the gin as a major contribution to the solution of a part of the air pollution problem. Integrated with improvements in conveying, it would appear to have considerable potential in improving efficiency and reducing costs, and in controlling the trash nuisance at and in the vicinity of gins. There has been no indication, however, that the air handling improvements have solved the problem of undegraded pesticide residues, either at the gin or in trash disposal methods, whether this disposal is accomplished by burning or by other means.

It is indicated that the absence of improved bale packaging and automatic sampling has placed American cotton at a disadvantage in export markets. Unless this problem is considered to have a suitable solution already at hand, but unapplied within the industry, research in this area should be developed. The means for its development indicate a need for engineering assistance. The research feedback of information and methods to the ginning system would be an improvement in baling capacity with decreased labor at high-speed gins.

Structures for Crop and Machinery Storage and Plant Growth

The complicated problems encountered in providing protection to products of agricultural production, machines and equipment, and farm service facilities for curing and processing should be given continuous programing. The magnitude and scope of these problems are evidenced by the great quantities of crops and materials handled, stored, graded and initially processed on the farm. For example, involved in these problems are five billion bushels of feed grains, 200 million tons of hay and silage, 2½ million bushels of fruit, 34 million hundredweight of potatoes, as well as large amounts of fertilizers and supplies. All aspects of handling these materials constitute most important operations in the production-to-market link of agriculture. There is also an aggregate of some seven million tractors, combines, and other valuable farm machines needing storage and repair and maintenance facilities. The continual rapid change in farming practices requires new information currently.

It is interesting that 83 percent of the commercial greenhouse area in the United States is for florist crops, 4 percent for nursery crops, and 13 percent for vegetables, while greenhouse crops equal only 2 percent of all farm crops sold. There is further need for work to control environmental and measuring conditions in these growth chambers.

Crop storage structures need more emphasis, especially the controlled atmosphere type. The problem of gastight versus tower and bunker silos is still a mystery to many farmers. It appears that work on wilted grass silage storage is satisfactory, but work needs to be continued on hay wafer storage and handling to facilitate automatic mechanical handling and feeding.

CO_2 studies and controlled environments for growing flowers appear to have promise and are justified. A portable greenhouse study planned for the future should be useful. The studies viewed at Beltsville on lighting, cooling and motion look promising.

Livestock Engineering (Except Electrical)

Availability of adequate labor for the production of livestock, poultry, milk and eggs has become a critical problem. The chores associated with this production are onerous and confining--24 hours a day, 7 days a week and 52 weeks a year. Farm labor is finding more attractive and better paying employment in the cities and in newly established nearby rural industries.

To meet the competition and remain in business, the livestock producer must increase the efficiency and labor attractiveness of his operation by improving the design and layout of his facilities and by using mechanical equipment to supplement available manpower. The problem is national in scope and involves all types of livestock and poultry enterprises. An integrated engineering, economic and animal husbandry research program is needed to develop and evaluate, under controlled conditions of environment and management, alternative designs, layouts, equipment, controls and production systems.

To meet these urgent and critical needs it is again recommended that the livestock engineering research program be greatly strengthened and expanded. It is noted that a considerable amount of work is being done in this area by the State Experiment Stations so it would appear logical to first expand the extramural effort to provide adequate coordination with the State programs.

Waste Disposal and Water Supplies

The urgent need for greatly expanding the work on waste disposal is emphasized by the Committee for the third time. During this period there has been partial or complete failure of certain methods which gave promise. This points only to greater need for this research work. In addition to the particular need relating to wastes produced on farms, there is also need for research on ways to handle all wastes from agricultural industry, as well as some others that might be best disposed of by application on agricultural lands.

Livestock concentrations, with the resultant quantities of animal wastes and objectionable odors, demand research to find satisfactory methods and means for the disposal of these wastes. We again strongly urge that an adequate expansion of both personnel and facilities to speedily carry out this work to a satisfactory conclusion be provided. We recommend that this work be headed up by the Agricultural Engineering Research Division, Agricultural Research Service, including personnel from all disciplines who can aid in conducting this work.

We believe that personnel familiar with agriculture and agricultural practices are essential to the rapid and satisfactory conduct of this research on agricultural wastes. Organic wastes, odors, smoke, and dust resulting from on-the-farm operations should be considered as parts of this work. If the answers to problems can be best obtained by contractual services or grants, then these alternatives should be investigated.

Pure water is a basic requirement of farmstead operations. Tremendous quantities of pure water are required to meet the needs of humans, livestock operations, crop cleaning and processing, as well as other uses. The demands for water are continually increasing in the face of increasing sources of contamination. Studies should be initiated immediately to find ways and means of insuring adequate supplies of pure water to meet these farm requirements. Where contamination of available water cannot be prevented, satisfactory methods for effectively and economically treating the water to make

it safe for use should be developed. These recommendations concur with those of the National Agricultural Research Advisory Committee in its 1965 and 1966 reports.

Farm Electrification

National Laboratory

The Committee wishes to restate its conviction, as expressed in previous years, that a central farm electrification research laboratory, staffed by highly competent engineers, and adequately funded, should be established. The purpose of this laboratory would be to pursue intensive investigations, cooperative with other disciplines, on areas such as: (1) fundamental relationships between electromagnetic radiation and biological matter including plants, animals, and insects; (2) use of electric energy for automating agricultural tasks and reducing manual labor requirements; and (3) improved utilization of electric energy for better rural living. The scope of this needed work is also detailed in 87th Congress Hearings before the Subcommittee on Agricultural Appropriations--U.S. Senate, HR 12648, 1963.

Electric Equipment for Farm Labor Reduction

A concentrated program is needed for research on electric farmstead equipment for handling feeds and other materials involved in livestock and milk production. During the period 1940-44 to 1965 the labor required to produce corn was reduced from 25.5 to 5.8 man-hours per acre, a 77 percent reduction. During a comparable period labor required in man-hours per milk cow was reduced from 142 to 84, a 41 percent reduction. Comparable figures for beef cattle are 4.0 and 2.4 man-hours per 100 pounds, which is only a 40 percent reduction in man-hours per 100 pounds. Automatic equipment is needed at reasonable cost that will eliminate laborious tasks and provide more efficient production.

In view of the great and urgent need for labor and cost reduction in the farmstead area, the allocation of only 3.8 scientific man-years to USDA research in this entire area appears woefully inadequate and particularly so in the field of livestock equipment which receives only 1.3 scientific man-years of effort. Because the application of electric power to replace human effort appears to offer such promising potential here, a doubling and then a redoubling of research effort in this area would appear quite justified and is urgently recommended.

The cooperative work in special equipment for apiaries should be continued. This segment of agricultural production is small, but it affects some of the larger segments through pollination activity where no adequate alternative has been found. The modest support for this area of work would seem to provide the least cost alternative in assuring the continuation of pollination service to crops requiring beneficial insect activity.

Farm Electric Service and Research Instrumentation

Provisions should be made to follow the rapid changes in power requirements on farms, especially in line with much higher current demands of larger farm motors. These demands require coordination of efforts to secure answers to problems which arise for power suppliers, farmers and equipment manufacturers. We believe the Department should follow these conditions and serve as a leader in the solution of such problems.

Complex research studies require intricate and special instrumentation, much of which is not available commercially. We recommend that personnel and facilities be provided through which other disciplines can secure help in the development and/or construction of instrumentation needs.

Electric and Solar Equipment for Environmental Control

The interdisciplinary work underway to develop equipment and study the factors such as light, temperature, nutrients, etc., and their manipulation to control plant growth and behavior is commended. The many possibilities of this work in providing new knowledge of plant growth factors, their manipulation to control growth rate or timing and other factors warrants continuation and expansion of this work.

Rural Dwellings

The research effort in this area appears to be in line with the needs and is being carried out in an effective manner. Therefore, it is recommended that the work be continued as planned.

PROTECTION OF PLANTS AND ANIMALS

Crop Pest Control Techniques and Equipment

Pests (weeds, insects, and diseases) may be considered in crop production systems to be the contaminants which must be controlled to limit constraints on system function and output. Pest control is an operational input which can be considered to have an economic cost which approaches as a limit, the value of the increment yield or increment quality attributable to the performance of the pest control operation. Evaluation of the cost effectiveness of alternative methods is required, together with residual effects and the responsibility for failure to confine application to the area intended.

Commendation is offered for the range of alternatives under investigation in mechanical, chemical, and electrical/radiant energy means, that the crop grower may select the procedure most suitable for the crop, the physical constraints of the environment, and the economic cost. The input to production is essential, however performed, and investigations must be continued

and expanded if the needs of both grower and consumer are to be met in this critical item in food and fiber production.

Physical Methods of Insect Control

Electromagnetic and ultrasonic energy work toward the control of insects and treatment of seeds and plant products is commended. We recommend that the present work be continued, with emphasis placed on the effectiveness of light traps in controlling various insects. A part of these studies should be to determine the density requirements of the traps for different crops and insects. Where adequate control cannot be accomplished by light traps themselves, studies should be made of their use to determine when chemical or other methods of treatment are needed so that a minimum of such treatments will be required. This work, in cooperation with the entomologists, should be continued and pointed toward developing recommendations for the use of these traps commercially for either of the above purposes and to determine other insects against which traps might be effective.

Research to further study the radiation wave lengths, ultrasonics or other stimuli as to their attraction or effect on various insects should be continued to supplement the trap studies, and their possible application to their use in controlling insects or possibly plant and animal diseases considered.